BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B69 12101

SUBJECT: Apollo 12 Launch Weather Conditions - Case 320

DATE: December 30, 1969

FROM: W. O. Campbell

ABSTRACT

Comparison of Apollo 12 launch weather conditions to mission rules not only shows that conditions were within rules but also serves as a basis for reviewing candidates for improvement.

Candidates for avoiding lightning by changing mission rule weather requirements are generally subjective, possibly more so than the objective nature of present mission rules. Cloud top height or a composite of weather phenomena to indicate turbulence and static charge build-up may be a useful criterion. Usefulness of any phenomenon as a criterion depends upon the amount of pertinent data already collected at KSC. Years of data are usually required to establish the statistical validity of a weather phenomenon.

Another candidate is the stationing in the LCC during countdown of a meteorologist equipped with a television link to permanently-mounted charts in the Manned Spacecraft Operations Building (MSOB) weather office. This candidate exerts a multiplier effect on whatever weather phenomenon is chosen. The television link partially alleviates the problem of decoupling the meteorologist from familiar weather charts with consequent impairment of weather forecasting ability. Using a compatible pair of meteorologists (one at the MSOB, one at the LCC) may further alleviate the decoupling on a short term basis. The two would exchange places at selected times during the countdown. Since this candidate is subjective, even personal, its utility is a function of the personnel involved.

(NASA-CR-109682) APOLLO 12 LAUNCH WEATHER CONDITIONS (Bellcomm, Inc.) 24 p

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MEMORANDUM FOR FILE

INTRODUCTION

There has been speculation as to the meteorological conditions at the Apollo 12 launch. The weather map, surface winds, hourly weather observations, weather radar observations, sferics* and other records provide data to determine launch weather conditions. Mission rules set forth launch weather requirements. Comparison of requirements with conditions provides better understanding of both, which is a prerequisite for any contemplated improvement, whether in rules or other program areas.

LAUNCH WEATHER REQUIREMENTS - MISSION RULES

Appendix I quotes verbatim wind and weather portions of the Apollo 12 launch mission rules.[1] Of immediate interest are:

1. Forward observer restriction on ceiling: 500 feet (ft)**

2. Forward observer restriction on visibility: 3 nautical miles (nm)**

3. (Pad Abort) wind restriction at 162 ft: 25 knots

4. Thunderstorm: "..... space vehicle will not be launched when its nominal flight path will carry it through a cumulonimbus (thunderstorm) cloud formation." (Rule I-40 .2)

5. Egress rules, ingress to access arm retract to liftoff: "A meteorological forecast of thunderstorm activity is required when thunderstorms are predicted to occur within a 20 statute mile radius of the space vehicle. When thunderstorms are in

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*Sferics equipment detects thunderstorms in KSC area by triangulation on lightning flashes.

**From 225 to 360 degrees from space vehicle.

progress within a 5 statute mile radius of the vehicle, consideration will be given by the Launch Director to flight crew egress." (Rules I-609.9, I-610.6)

LAUNCH WEATHER CONDITIONS

The first three launch weather requirements can be verified by quoting independent observations made by two groups: (1) NASA Spaceflight Meteorology Group personnel at the Manned Spacecraft Operations Building (MSOB), (2) Cape Weather Station Personnel (CWS) located near Pad 11. These observations (obs) typically vary because they were made about 6.5 miles apart in rainshower conditions: They are:

	ITEM	MISSION RULES RESTRICTION	MSOB OBS.	CWS OBS.(2)
1.	Ceiling	500 ft	800 ft broken	2100 ft overcast
			4,000 ft broken	
			10,000 ft broken	
2.	Visibility	3 nm	7 miles in rainshower	4 miles in rainshower
3.	Abort Wind	25 knots peak	11 knots at 270 degrees fairly steady	5 knots at 290 degrees

Both offices were in operation during the launch. CWS was making hourly and special observations. The MSOB weather office was in frequent telephone communciation with the Launch Director and was making weather observations appropriate for this purpose at the MSOB.

The remaining requirements 4 and 5 are satisfied by examination of available data for observed evidence of thunderstorms.

Area Map

Figure 1, the 1000 Eastern Standard Time (EST) weather map (1500 Greenwich Time) shows the general area conditions, with Figure 2 illustrating the station plotting model. The synoptic situation is one of rainshowers caused by convective activity associated with a cold front passing through the area. The nearest reporting stations are Orlando and West Palm Beach (Figure 2 detail). Orlando shows a rainshower $\dot{\nabla}$;

the latter shows cumulus congestus build-ups plus alto-cumulus . The nearest cumulonimbus (thunderstorm) cloud is reported at Key West, too far away to represent Pad A conditions. At the time of the map, no thunderstorms (TSTMS) were reported in the KSC area.

Appendix II offers a brief explanation of a cold front and cumulus clouds denoting amount of convective activity.

Weather Radar

The MSOB radar scope showed the frontal area at KSC to consist of two rainshower bands with scattered showers between. See Figure 3 illustrating verbal reports.[3] The second band was apparently causing the reported precipitation at launch. No cumulonimbus cloud was reported. Cloud tops were reported at 18,000 to 20,000 ft. Daytona reported one at 27,000 ft[4] at 1043 EST, with remaining tops at 22,000 ft.

Sferics

The sferics equipment which was in operation at the MSOB weather office had detected several TSTMS the day before, but had shown no close-by lightning before the launch.[3] There was an indication of lightning after the launch.

Potential Gradient and Corona Current Instrumentation

KSC potential gradient (PG) and corona current (CC) instrumentation cover the area as shown in Figure 4. They are listed in mission rules, along with other monitors, for instrumentation support of launch vehicle LH_2 loading. Records[5] from all eight sites are available. TSTMS on November 13 caused activity on PG and CC charts from seven sites, thus providing a calibration reference for visually judging comparative intensity of the traces at launch on November 14. Seven sites showed at launch a modestly disturbed field typically associated with rainshowers[5] but not disturbed to the extent caused by TSTMS on the previous day. This instrumentation responds to many weather phenomena other than TSTMS of mission rule concern. Interpretation is most informative when accomplished by resident meteorologists to resolve ambiguities. For example, a cumulonimbus cloud forming over Orlando can throw up an anvil at 40,000 to 50,000 ft, extending to KSC, setting up high PG readings.[6] Although

PG readings would appear ominous because of the charge distribution in the anvil, KSC TSTM probability would be immediately discounted by a resident meteorologist. Appendix III concludes that TSTM ambiguities are the rule rather than the exception by reviewing models of charge distribution in clouds and the many opposite conclusions about TSTMS that researchers have made using observed data.

Hourly Observations

As the name implies, hourly observations are taken at least every hour. In addition, a special observation is made whenever a significant change[7] occurs, such as ceiling, sky condition, visibility, precipitation, and TSTM beginning, intensity increase, or end. The November 14 record[2] at CWS shows at 11:22 a.m. EST a 2100 ft overcast ceiling with four mile visibility in rainshower, with no TSTM reported.

LAUNCH WEATHER REQUIREMENTS VERSUS ACTUAL CONDITIONS

The following checklist summarizes preceding discussions:

	ITEM	MISSION RULE REQUIREMENT FOR LAUNCH	ACTUAL CONDITION AT LIFTOFF
1.	Ceiling	500 ft	800 ft (MSOB)* 2100 ft (CWS)*
2.	Visibility	3 nm	7 miles (MSOB)* 4 miles (CWS)*
3.	Wind (Abort)	25 knots peak	11 knots steady state (MSOB)* 5 knots (CWS)*
4.	Thunderstorm	no launch through	none reported in area
5.	Thunderstorm	if within 5 miles, consider crew egress	none reported in area

*Readings taken at two points separated by >6 miles.

REFINEMENT CANDIDATES

These fall generally into two classes, depending on desired effect: avoidance of lightning, and minimization of effect of lightning. While lightning is of immediate interest from Apollo 12, the accompanying/preceding turbulence is of equal, or more, importance.

Avoidance Candidates

Contemplated refinements would necessarily involve the use of some weather phenomenon (or combination) as a basic continue/hold criterion. The problem is one of choosing a phenomenon with enough years of already-collected data to validate the phenomenon and thus provide an objective and unambiguous basis for improvement without penalty on future missions. Data are customarily collected for years to establish the statistical validity of a weather pattern.

Hold* in Rainshower: Not all rainshowers produce lightning; Apollo 12 strokes may not have been solely the result of nature; conservatism could impose penalty on future missions.

Hold With Front in Area: More selective than rainshower criterion; however, some fronts are inactive; Apollo 12 launch weather can also be caused by September-October TSTMS[6] and showers forming over Atlantic Ocean; subjective.

Hold With Potential Gradient and Corona Current Data: High readings can be caused by cumulonimbus anvil over KSC from TSTMS[6] as much as 50 miles away; ambiguous, subjective. See Appendix III.

Cloud Top Height Composite: Height plus bottoms, cloud type and freezing level permit potential instability estimate of turbulence and convective activity, which, in turn, may correspond roughly with static charge build-up in cloud. Data during countdown would depend upon weather radar cloud height measurements or mission support pilot reports, or both. Attractiveness depends upon availability of KSC electrification and turbulence data to establish go/no-go value.

When Lightning Reported Within X Miles, Hold for Weather Re-Appraisal: No nearby lightning reported before Apollo 12 launch; places premium on sferics, PG and CC equipment and team of local

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*"Hold" indicates sense of the constraint, not exact wording.

observers. Possibility of undetected lightning or man-made interference simulating lightning. Quantitative observation, subjective interpretation.

Prelaunch Use of Rockets Artificially to Trigger Lightning from Low Clouds - Newman has employed this technique[8] successfully at sea, reporting two artificially-induced discharges for five rocket firings with 1000 foot trailing wire. He further reports concerning another experiment that a rocket ion trail may be kept conductively ionized by application of a low current between pulses of artificial lightning; a ship of the tender class was outfitted for the tests. While of interest in relation to the concept of artificially-triggered lightning, use of the technique for Apollo would impose operational problems of split-second timing as well as require bringing a new capability up to operational usefulness.

Establish Weather Forecast/Interpretation Capability in LCC:

This candidate exerts a multiplier effect on whatever weather phenomenonis chosen as a continue/hold criterion.

Placing a meteorologist in the LCC without data not only decouples the meteorologist from required data but also creates a new-environment situation, both of which tend to impair the forecasting ability of the meteorologist.

Weather forecasting requires almost continuous access to many types of data, especially in rapidly-changing situations such as frontal passages, TSTMS, and squall lines. Data access provisions could range from (1) establishment of a complete weather station at the LCC to (2) establishment of a television link from the LCC to the MSOB weather office suitable for viewing weather charts permanently mounted there. Partial decoupling of the meteorologist from his data occurs even in the latter case.

The decoupling and new environment problems could be alleviated further by having two meteorologists work as a team with one in the MSOB weather office, the other in the LCC, using television and telephone links. At appropriate times in the countdown the two would exchange places, thus maintaining continuity with the weather.

This candidate is subjective, even personnel; thus its utility is a function of the personnel involved.

Minimization Candidate

The subjectiveness in using weather phenomena to avoid lightning may make it more cost-effective to consider other measures, such as providing additional interstage paths specifically for heavy currents associated with lightning. These paths would be an addition to, but not a substitute for, the existing electrical circuit grounding system. The candidate is objective and quantitative, but may impose a payload penalty.

SUMMARY AND CONCLUSION

Weather and wind conditions at Apollo 12 launch were within mission rules.

Mission rule lightning avoidance candidates suffer generally from ambiguity, lack of objectivity, and depend to some extent on local forecasting experience. If weather analysis capability is implemented in LCC for countdown, the meteorologist would be aided by real time visual access to permanently-mounted records and charts at the observing station to alleviate decoupling from weather data. Using a compatible pair of meteorologists (one at MSOB, one at LCC) may further alleviate the decoupling. The two would exchange places at appropriate times during the countdown.

Refinement of other program areas requires investigation before a trade-off for program effectiveness can be made.

William O. Campbell

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W. O. Campbell

Attachments
Figures (6)
Appendices I-III

References

1. Launch Mission Rules Apollo 12 (SA-507/CSM-108/LM-6), KSC, basic, October 2, 1969.

2. CWS hourly and special weather observations, November 13 and 14, 1969.

3. Nagler, Kenneth M., Chief, Space Operations, Support Division, U.S. Department of Commerce, conversations November 21 and December 8, 1969.

4. Radar Weather Observations, Daytona Beach, Florida, November 13 and 14, 1969.

5. Potential gradient and corona current charts for November 13 and 14, 1969, courtesy J. R. Nicholson, Chief, KSC Weather Office.

6. Amman, Ernest A., KSC, TS-MET, conversations December 3 and 12, 1969.

7. Manual of Surface Observations (WBAN) Circular N, Seventh Edition, Departments of Commerce, Air Force and Navy, U.S. Government Printing Office, April, 1966, p. 9-3,4.

8. Problems of Atmospheric and Space Electricity, Proceedings of the Third International Conference on Atmospheric and Space Electricity, Montreux, Switzerland, May 5-10, 1963, edited by Samuel C. Coiniti, Elsevier, Amsterdam, 1965, Section VI.4 by M. M. Newman, pp. 482-490.

9. Physical Meteorology, John C. Johnson, MIT Press, 1954, p. 302, 303.

10. Atmospheric Electricity, J. Alan Chalmers, Pergamon, Oxford, second edition, 1967.

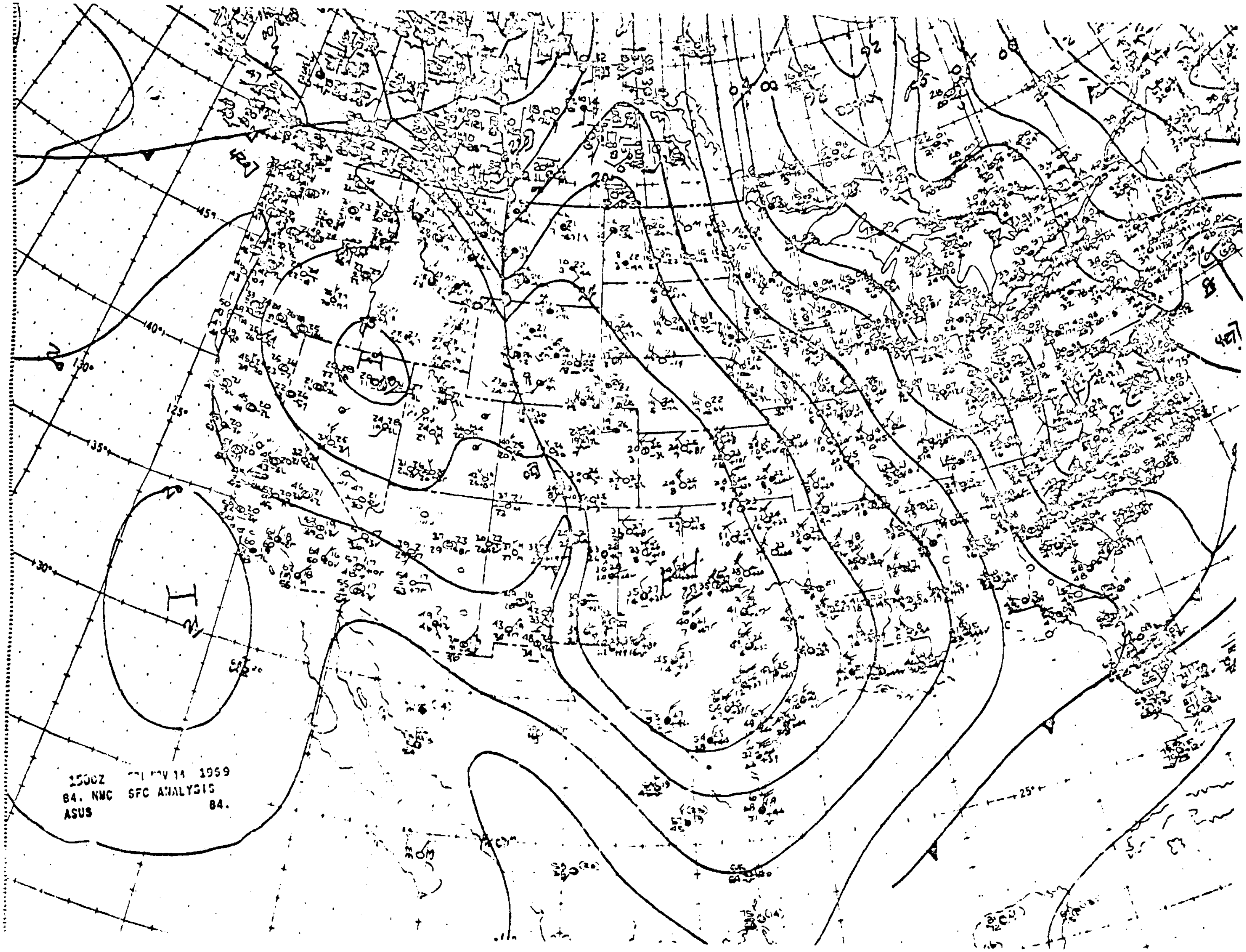
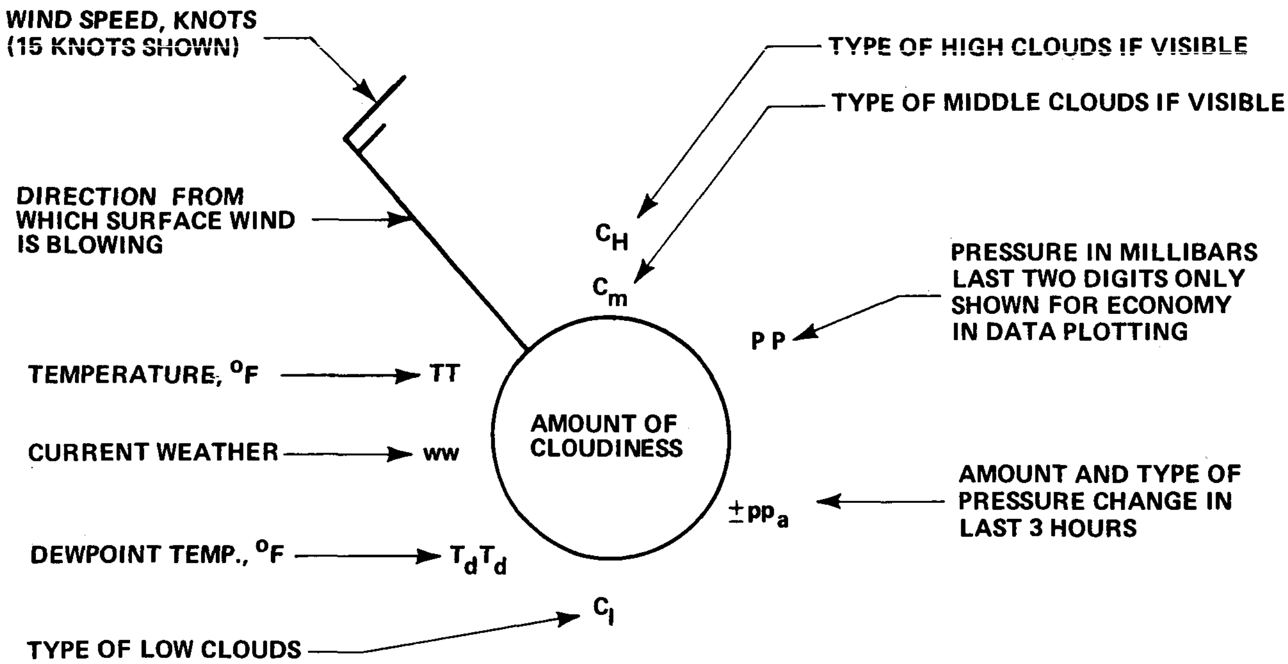


FIGURE 1 - WEATHER AT 1000 EST, 14 NOVEMBER, 1969



EXAMPLES:

ww RAIN SHOWERS

C_l CUMULUS BUILD-UPS

CUMULONIMBUS (MUST ALWAYS BE PRESENT BEFORE THUNDERSTORM CAN OCCUR)

pp_a; +10 PRESSURE FELL THEN ROSE; 1.0 MILLIBAR NET 3 HOUR CHANGE

CLOUDINESS: SCATTERED. OVERCAST

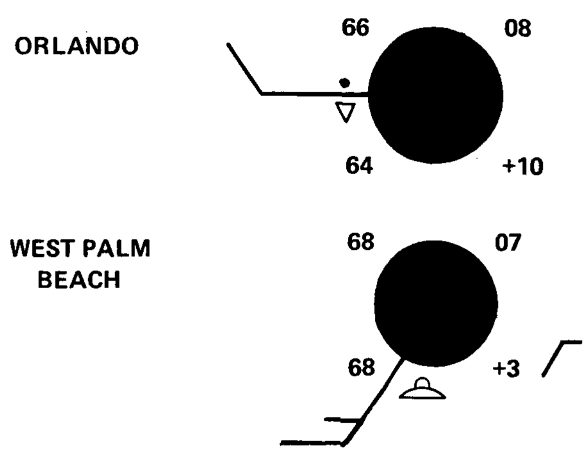
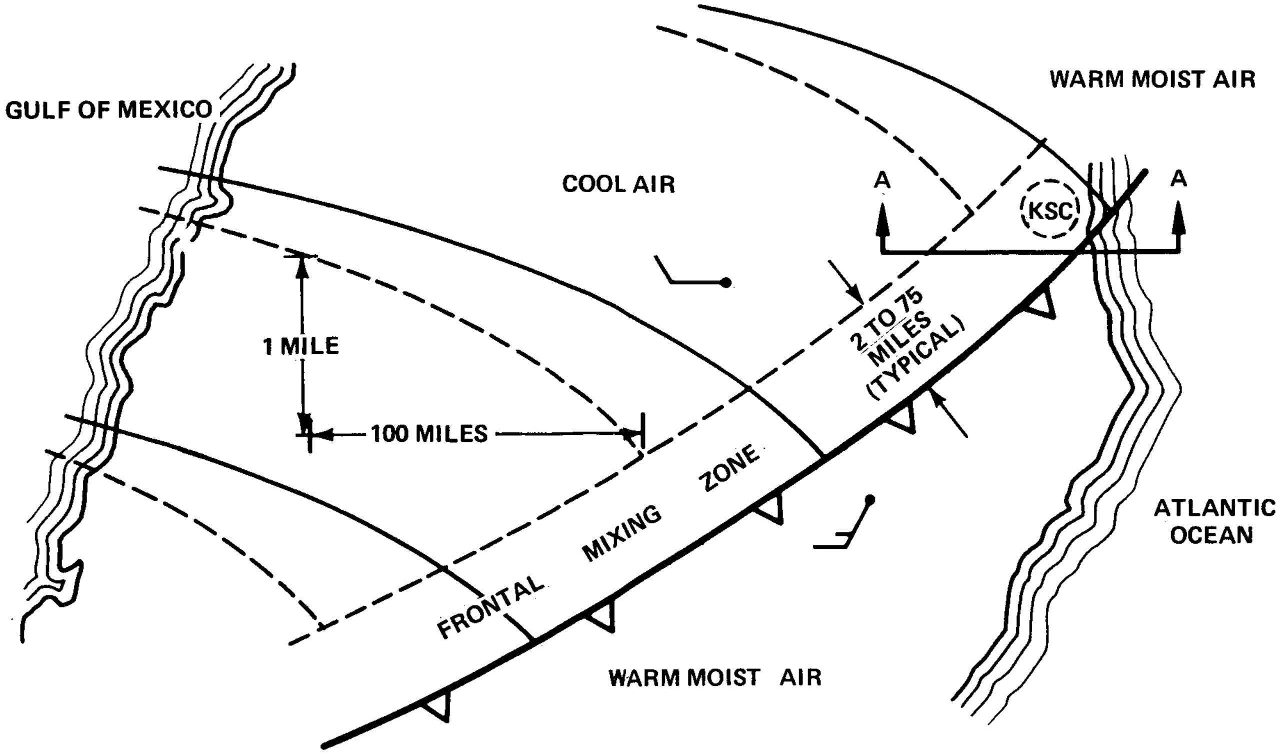
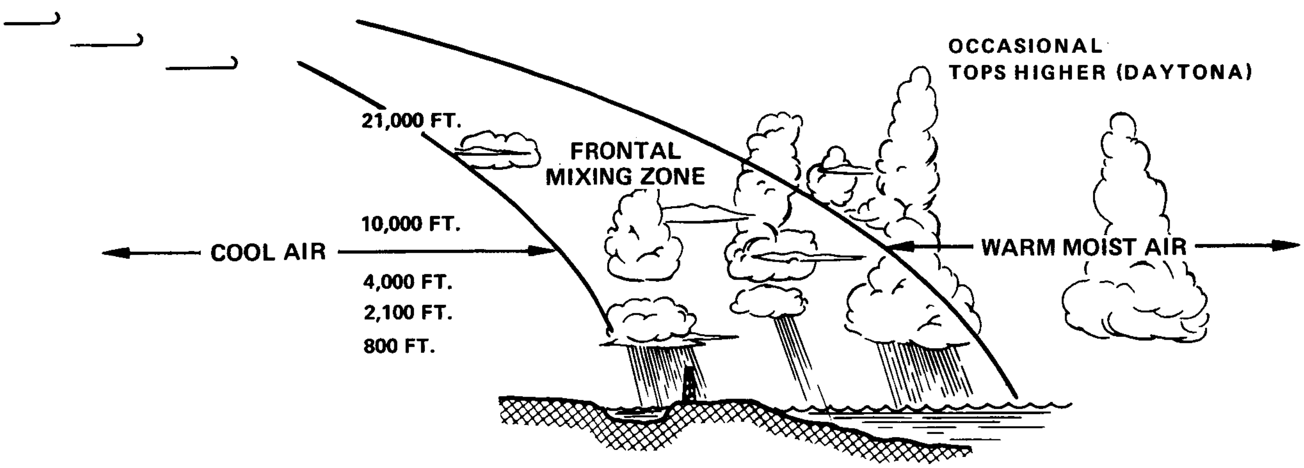


FIGURE 2: WEATHER STATION DATA PLOTTING MODEL WITH TWO 1000 EST NOVEMBER 14, 1969 EXAMPLES





SECTION A – A
LOOKING NORTHWARD

* CLOUD COVER AND PRECIPITATION PATTERNS IN FRONTAL ZONES VARY WIDELY WITH SEASON, LATITUDE, TIME, FRONTAL INTENSITY, RELATIVE HUMIDITY.

FIGURE 3 - COLD FRONT * AT KSC

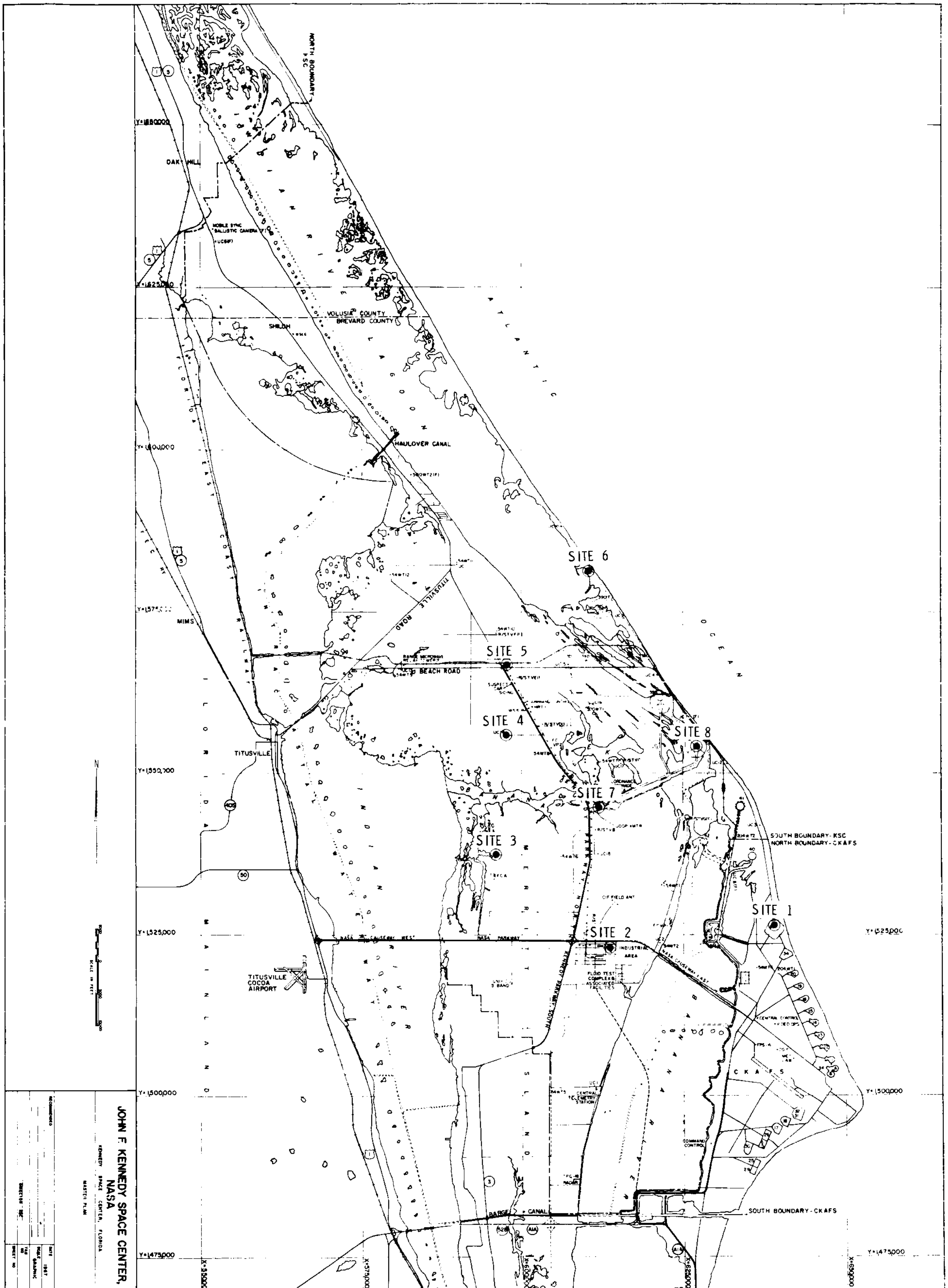


FIGURE 4 - LOCATION OF POTENTIAL GRADIENT (PG) AND CORONA CURRENT (CC) INSTRUMENTATION FOR APOLLO 12 LAUNCH

APPENDIX I
MISSION RULE WEATHER AND WIND RESTRICTIONS ON APOLLO 12 LAUNCH

WEATHER RESTRICTIONS:

1-400 CEILING AND VISIBILITY RESTRICTIONS:

1. MANDATORY CONDITIONS:

A. KSC FORWARD OBSERVER RESTRICTIONS:

VISUAL MONITORING OF ABORT CONDITIONS BY FORWARD OBSERVERS AT SITES NO. 1, 2, AND 3, IS MANDATORY, REFERENCE "FLIGHT CREW SAFETY RULES" SUBSECTION, ITEMS 1-642 THRU 1-646 AND 1-652 THRU 1-654. THE FOLLOWING RESTRICTIONS ARE IMPOSED:

CEILING: 500 FT*
VISIBILITY: 3 NM*

* FROM 225° TO 360° AZIMUTH FROM THE SPACE VEHICLE.

B. RANGE SAFETY RESTRICTIONS:

NO CEILING OR VISIBILITY RESTRICTIONS WILL BE IMPOSED PROVIDING 1.16 (CAPE FPS-16) AND 19.18 (MERRITT ISLAND TPQ-18) RADARS AND IU C-BAND BEACON NO. 1 ARE OPERATIONAL.

2. HIGHLY DESIRABLE CONDITIONS:

PHOTOGRAPHIC COVERAGE OF MAX Q AND LET JETTISON FROM THE ALOTS AIRCRAFT IS HIGHLY DESIRABLE. (FOR HARDWARE ENTRY, SEE SECTION 4, "TECHNICAL SUPPORT OPERATIONS," ITEM 4-408.)

WEATHER RESTRICTIONS (CONTINUED):

1-401 SURFACE WIND RESTRICTIONS PRIOR TO LIFTOFF (SPACE VEHICLE STRUCTURAL AND GSE INTERACTION LIMITS):

1. GENERAL:

A. THE LAUNCH DIRECTOR WILL ASSESS WIND CONDITIONS RELATIVE TO SPACE VEHICLE STRUCTURAL AND GSE INTERACTION LIMITS PRIOR TO START OF THE FOLLOWING COUNTDOWN ACTIVITIES, AND WILL CONTINUE OR HOLD THE COUNTDOWN ACCORDINGLY:

(1) LAUNCH VEHICLE CRYOGENIC LOADING (APPROX. T-8 HOURS 15 MINUTES).
(2) FLIGHT CREW INGRESS (APPROX. T-2 HOURS 40 MINUTES).
(3) ACCESS ARM RETRACTED TO PARK POSITION (APPROX. T-43 MINUTES).
(4) ACCESS ARM FULLY RETRACTED (APPROX. T-5 MINUTES).

B. THE SPACE VEHICLE SHOULD NOT BE EXPOSED TO WINDS THAT RESULT IN EXCEEDING THE SPECIFIED PEAK BENDING MOMENTS. THE APOLLO ACCESS ARM SHOULD BE DISCONNECTED BEFORE EXCEEDING THE SPECIFIED PEAK BENDING MOMENTS IN ORDER TO PREVENT DAMAGE TO THE SPACE VEHICLE. THE BENDING MOMENT LIMITS WILL NOT BE EXCEEDED IF THE SPECIFIED WIND VALUES AT THE 60-FOOT LEVEL ARE OBSERVED. IF THE BENDING MOMENT LIMITS ARE EXCEEDED, AN ASSESSMENT OF POSSIBLE DAMAGE IS REQUIRED BEFORE PROCEEDING.

C. DAMPER TRANSITION WILL NOT BE ATTEMPTED IF THE MEASURED BENDING MOMENT IS UNAVAILABLE OR THE PEAK WIND VELOCITY AT THE 60-FOOT LEVEL IS PREDICTED TO EXCEED 30 KNOTS. HOWEVER, IF THE WIND IS PREDICTED TO EXCEED 30 KNOTS AND THE BENDING MOMENT IS AVAILABLE, A REAL TIME ASSESSMENT OF OBSERVED AND PREDICTED CONDITIONS WILL BE MADE BEFORE PROCEEDING WITH DAMPER TRANSITION.

D. IN THE EVENT THAT SURFACE WINDS APPROACH THE SPECIFIED MARGINAL WIND VALUES, THE MSFC/MSC WIND MONITORING TEAM AT THE HOSC WILL EVALUATE THE ACTUAL WIND PROFILE AND EXPECTED SPACE VEHICLE RESPONSE, AND WILL PROVIDE RECOMMENDATIONS TO THE LAUNCH DIRECTOR IF REQUIRED.

E. ALL SPECIFIED WIND VALUES ARE REFERENCED TO 60 FEET ABOVE NATURAL GRADE AND ARE FOR THE WORST WIND DIRECTION; ALL BENDING MOMENTS ARE REFERENCED TO STATION 790 (S-IC INTERTANK AREA).

F. WINDS IN EXCESS OF 64 KNOTS ARE DEFINED AS OF HURRICANE FORCE, AND ARE NOT SPECIFIED IN THIS DOCUMENT.

1-401 (CTD)

CONDITION	L/V PROPELLANT LOADING (%) S-IC LOX	S-II LOX	S-II LH2	S-IVB LOX	S-IVB LH2	DAMPER POSIT.	S/F	S/V STRUCTURAL LIMITS PEAK WIND VELOCITY (KNOTS)*	PEAK BENDING MOMENT (10^6 IN-LB)	AAA TRACKING LIMITS PEAK WIND VELOCITY (KNOTS)*	PEAK BENDING MOMENT (10^6 IN-LB)
4. LAUNCH COUNTDOWN: (S-IC RP-1, CSM/LM HYPERGOLICS, CSM CRYOGENICS, AND LM SHE FULLY LOADED):											
MSS AT VEHICLE	0	0	0	0	0	ON	1.25	64	204	64	177
MSS AT VEHICLE	0	0	0	0	0	OFF	1.25	30**	177	28**	128**
MSS REMOVED	0	0	0	0	0	OFF	1.25	30**	177	28**	128**
MSS REMOVED	0	0	0	0	0	ON	1.25	64	240	64	177
S-IVB LOX LOADED	0	0	0	100	0	ON	1.25	64	162	64	162
S-II LOX LOADED	0	100	0	100	0	ON	1.25	64	183	64	183
S-IC LOX LOADED	100	100	0	100	0	ON	1.25	64	183	64	183
S-II LH_2 LOADED	100	100	100	100	0	ON	1.25	64	183	64	183
S-IVB LH_2 LOADED	100	100	100	100	100	ON	1.25	60	172	60	172
S/V FULLY LOADED	100	100	100	100	100	OFF	1.25	60	172	60	172
S/V FULLY LOADED	100	100	100	100	100	OFF	1.40	60	172	60	172

NOTES: (1) * THE SPECIFIED PEAK WIND VELOCITY VALUES ARE REPRESENTATIVE, AND DO NOT NECESSARILY REFLECT TRUE SPACE VEHICLE STRUCTURAL LIMITS. THESE WIND VALUES WILL BE USED ONLY IF THE MEASURED BENDING MOMENT IS UNAVAILABLE.

(2) ** THESE VALUES ARE AZIMUTH DEPENDENT (REFERENCE SUPPLEMENTARY POLAR PLOTS).

APPENDIX I

WEATHER RESTRICTIONS (CONTINUED):

1-402 SURFACE WIND RESTRICTIONS FOR LIFTOFF (SPACE VEHICLE LAUNCH RELEASE LIMITS):

THE SPACE VEHICLE WILL NOT BE LAUNCHED FOR ANY OF THE FOLLOWING CONDITIONS PREDICTED TO OCCUR AT TIME OF LAUNCH:

1. SPACE VEHICLE STRUCTURE:

BENDING MOMENT AT STATION 790 (S-IC INTERTANK AREA) EXCEEDING 81.5 MILLION INCH-POUNDS. (IF THE MEASURED BENDING MOMENT IS UNAVAILABLE, THE SPACE VEHICLE WILL NOT BE LAUNCHED WITH A PEAK WIND SPEED EXCEEDING 30 KNOTS AT THE 60-FOOT LEVEL, HOWEVER, IF THE 30 KNOT WIND SPEED LIMIT IS VIOLATED BUT THE MEASURED BENDING MOMENT WAS VERIFIED AS ACCEPTABLE AFTER PRIMARY DAMPER RELEASE, A REAL TIME ASSESSMENT OF OBSERVED WIND CONDITIONS WILL BE MADE TO DETERMINE ACCEPTABILITY FOR LAUNCH.)

NOTE: LAUNCH RELEASE IS PERMISSIBLE AT ANY 60-FOOT LEVEL WIND SPEED BELOW 30 KNOTS AND MAY BE PERMISSIBLE AT WIND VALUES BETWEEN 30 KNOTS AND 47 KNOTS DEPENDING ON WIND DIRECTION, PROFILE, AND DYNAMIC EFFECT ON THE SPACE VEHICLE. IN THE EVENT THAT SURFACE WINDS ARE FORECAST BETWEEN THESE LIMITS, THE MSFC/MSC WIND MONITORING TEAM AT THE HOSC WILL EVALUATE THE ACTUAL WIND PROFILE AND EXPECTED SPACE VEHICLE RESPONSE, AND WILL PROVIDE RECOMMENDATIONS TO THE LAUNCH DIRECTOR IF REQUIRED.

2. TOWER AND PLATFORM CLEARANCE:

THE FOLLOWING ARE NOMINAL WIND LIMITS DIRECTLY CORRESPONDING TO THE S-IC ACTUATOR (BETA) REDLINES:

A. PEAK WIND SPEED EXCEEDING 33 KNOTS FROM THE SOUTH AT THE 60-FOOT LEVEL.

B. PEAK WIND SPEED EXCEEDING 50 KNOTS FROM ALL OTHER DIRECTIONS AT THE 60-FOOT LEVEL.

IF EITHER FACTOR (WIND LIMIT OR BETA REDLINE) IS EXCEEDED, ADJUSTMENTS AS DESCRIBED IN SECTION 2, "LAUNCH VEHICLE OPERATIONS", IU FIGURES 2 AND 3, WILL BE NECESSARY FOR A LAUNCH DECISION. ALSO, REFERENCE ITEMS 2-720 THROUGH 2-727.

WEATHER RESTRICTIONS (CONTINUED):

1-403 SURFACE WIND RESTRICTIONS FOR LIFTOFF (COMMAND MODULE LAND LANDING LIMITS):

1. THE FLIGHT DIRECTOR WILL EVALUATE THE MODE 1 (TOWER) ABORT IP TRACK WIND SIMULATIONS AND WILL ADVISE THE LAUNCH DIRECTOR OF ANY PREDICTED PERIODS OF LAND LANDING PRIOR TO START OF CRITICAL COUNTDOWN ACTIVITIES (REFERENCE ITEM 1-403 (7) BELOW). IF THE FLIGHT DIRECTOR IS UNABLE TO PROVIDE THIS EVALUATION, A LAND LANDING WILL BE ASSUMED, AND THE SURFACE WIND RESTRICTIONS SPECIFIED IN ITEMS 1-403 (2) AND 1-403 (3) BELOW WILL BE APPLIED.

2. THE LAUNCH WILL NOT BE ATTEMPTED IF A MODE 1 (TOWER) ABORT WOULD RESULT IN A LAND LANDING WITH A SPACECRAFT HORIZONTAL VELOCITY COMPONENT OF GREATER THAN 54 FEET PER SECOND AT IMPACT.

3. THE SPACECRAFT WILL NOT REMAIN IN A TOWER ABORT MODE ON THE PAD IF A MODE 1 (TOWER) ABORT WOULD RESULT IN A LAND LANDING WITH A SPACECRAFT HORIZONTAL VELOCITY COMPONENT OF GREATER THAN 54 FEET PER SECOND AT IMPACT.

4. THE (LAND LANDING) WIND MONITORING TEAM WILL ANALYZE THE EFFECTS OF SURFACE WINDS ON THE SPACECRAFT VELOCITY AT IMPACT, AND WILL ADVISE THE LAUNCH DIRECTOR AND FLIGHT DIRECTOR PRIOR TO START OF CRITICAL COUNTDOWN ACTIVITIES (REFERENCE ITEM 1-403 (7) BELOW).

5. IF THE PEAK WINDS (FROM ANY DIRECTION AND REFERENCED TO 162 FEET ABOVE NATURAL GRADE) DO NOT EXCEED 25 KNOTS, THE SPACECRAFT HORIZONTAL VELOCITY COMPONENT AT IMPACT WILL NOT EXCEED 54 FEET PER SECOND.

6. IF THE PEAK WINDS (FROM ANY DIRECTION AND REFERENCED TO 162 FEET ABOVE NATURAL GRADE) EXCEED 25 KNOTS, OR IF THIS DATA IS UNAVAILABLE, THE WIND MONITORING TEAM WILL EVALUATE THE ACTUAL SURFACE WIND PROFILE TO DETERMINE THE PREDICTED SPACECRAFT HORIZONTAL VELOCITY COMPONENT AT IMPACT.

7. THE LAUNCH DIRECTOR WILL ASSESS THE LAND LANDING PROBABILITIES AND THE SURFACE WIND EFFECTS FOR MODE 1 (TOWER) ABORTS TO DETERMINE THEIR ACCEPTABILITY PRIOR TO START OF THE FOLLOWING COUNTDOWN ACTIVITIES, AND WILL CONTINUE OR HOLD THE COUNTDOWN ACCORDINGLY:

A. LAUNCH VEHICLE CRYOGENIC LOADING (APPROX. T-8 HOURS 15 MINUTES).
B. FLIGHT CREW INGRESS (APPROX. T-2 HOURS 40 MINUTES).
C. ACCESS ARM RETRACTED TO PARK POSITION (APPROX. T-43 MINUTES).
D. ACCESS ARM FULLY RETRACTED (APPROX. T-5 MINUTES).

NOTE: THE FLIGHT DIRECTOR WILL PROVIDE A LAND LANDING PROBABILITY ASSESSMENT TO THE LAUNCH DIRECTOR IN SUPPORT OF THE ABOVE ON A SCHEDULE AGREED TO BY KSC AND MSC, AND AS SPECIFIED IN THE "SPACE VEHICLE COUNTDOWN" TEST AND CHECKOUT PROCEDURE, TCP V-40300, VOLUME I.

WEATHER RESTRICTIONS (CONTINUED):

1-404 SPACE VEHICLE UPPER AIR WIND RESTRICTIONS:

1. PRELAUNCH SIMULATIONS OF THE SPACE VEHICLE RESPONSE TO UPPER AIR WINDS AT TIME OF LAUNCH WILL BE PERFORMED AT MSFC BY AN MSFC/MSC WIND MONITORING TEAM USING WIND DATA PROVIDED BY KSC. A C-BAND RADAR WILL BE UTILIZED TO TRACK JIMSPHERE BALLOONS RELEASED FROM THE LAUNCH AREA TO OBTAIN UPPER AIR WIND DATA FROM T-48 HOURS TO T+10 MINUTES ON A SCHEDULE AGREED TO BY KSC, MSFC, AND MSC. RESULTS OF THE WIND SIMULATIONS WILL BE TRANSMITTED VIA DATAFAX TO THE LAUNCH OPERATIONS MANAGER (OR TEST SUPERVISOR IN HIS ABSENCE) AT THE LAUNCH CONTROL CENTER. REPORTS WILL BE AVAILABLE AND PROVIDED AS CONSIDERED APPROPRIATE STARTING AT T-24 HOURS WITH A GO/NO-GO RECOMMENDATION TRANSMITTED PRIOR TO START OF CRYOGENIC LOADING. IF THE WIND SIMULATIONS INDICATE THAT WIND CONDITIONS ARE MARGINAL FOR LAUNCH, THE WIND MONITORING TEAM WILL REPORT THAT "LAUNCH WINDS ARE MARGINAL FOR LAUNCH". UPON RECEIPT OF THIS REPORT, THE LAUNCH OPERATIONS MANAGER WILL PLACE A CONTINGENCY PLAN INTO EFFECT WHICH WILL PROVIDE FOR A NEW JIMSPHERE RELEASE EACH HOUR. THE CONTINGENCY PLAN WILL REMAIN IN EFFECT UNTIL LIFTOFF HAS OCCURRED, THE LAUNCH IS SCRUBBED, OR A SUBSEQUENT REPORT STATES THAT "LAUNCH WINDS ARE NO LONGER MARGINAL FOR LAUNCH". THE WIND MONITORING TEAM WILL PROVIDE A REPORT TO THE LAUNCH OPERATIONS MANAGER FOR EACH JIMSPHERE RELEASE UNDER THE CONTINGENCY PLAN. (FOR HARDWARE ENTRIES, SEE SECTION 4, "TECHNICAL SUPPORT OPERATIONS," ITEMS 4-402, 4-213, AND 4-103.)

2. THE SPACE VEHICLE WILL NOT BE LAUNCHED WHEN ITS NOMINAL FLIGHT PATH WILL CARRY IT THROUGH A CUMULONIMBUS (THUNDERSTORM) CLOUD FORMATION.

APPENDIX I

1-609 EGRESS GROUND RULES (FLIGHT CREW INGRESS TO ACCESS ARM RETRACT):

9. A METEOROLOGICAL FORECAST OF THUNDERSTORM ACTIVITY IS REQUIRED WHEN THUNDERSTORMS ARE PREDICTED TO OCCUR WITHIN A 20 STATUTE MILE RADIUS OF THE SPACE VEHICLE. WHEN THUNDERSTORMS ARE IN PROGRESS WITHIN A 20 STATUTE MILE RADIUS OF THE VEHICLE AND THE FORMATION OR MOVEMENT OF A THUNDERSTORM IS PREDICTED TO OCCUR WITHIN A 5 STATUTE MILE RADIUS OF THE VEHICLE, CONSIDERATION WILL BE GIVEN BY THE LAUNCH DIRECTOR TO FLIGHT CREW EGRESS.

1-610 EGRESS GROUND RULES (ACCESS ARM RETRACT TO LIFTOFF):

6. A METEOROLOGICAL FORECAST OF THUNDERSTORM ACTIVITY IS REQUIRED WHEN THUNDERSTORMS ARE PREDICTED TO OCCUR WITHIN A 20 STATUTE MILE RADIUS OF THE SPACE VEHICLE. WHEN THUNDERSTORMS ARE IN PROGRESS WITHIN A 20 STATUTE MILE RADIUS OF THE VEHICLE AND THE FORMATION OR MOVEMENT OF A THUNDERSTORM IS PREDICTED TO OCCUR WITHIN A 5 STATUTE MILE RADIUS OF THE VEHICLE, CONSIDERATION WILL BE GIVEN BY THE LAUNCH DIRECTOR TO FLIGHT CREW EGRESS.

APPENDIX II

COLD FRONT AND CUMULUS CLOUDS

A cold front is a cold-warm air broad mixing zone moving such that cold air at the ground replaces warm air, causing convection. See Figure 3. Mild convection, present even in fine weather without a cold front, produces cumulus humilis, or cumulus of fine weather, symbol ⌓ . More pronounced convection carries moist air to moderate heights, producing cumulus congestus clouds, sumbol , which are sometimes accompanied by showery precipitation.

When convective activity is intense enough to carry saturated air to heights above the freezing level altitude, the upper portion of the cloud forms ice crystals which fan out along the upper air wind stream, forming a characteristic anvil shape. The weather symbol is , with the long point of the anvil indicating wind downstream direction at that level. These are cumulonimbus (TSTM) clouds. Extremes of precipitation and turbulence can be encountered within them.

APPENDIX III

CHARGE DISTRIBUTIONS IN CLOUDS

According to Johnson[9] charge distribution data that have been accumulated indicate that there are usually two regions of charge in large vertical development clouds: (1) a net negative charge, in cloud regions containing water droplets, and (2) a net positive charge in cloud portions containing ice crystals. This is only a nominal pattern with complex departures from this nominal pattern occurring quite often. Figure III-1 is an illustration of charge distribution in a cumulonimbus cloud, according to Johnson. The same author notes that many clouds have a positive region near the base where heavy rain exists.

Chalmers,[10] showing the model (Figure III-2) of Keuttner for a charge distribution in a TSTM cloud, shows positive charges in the lower region of melting graupel (soft opaque hail), negative charges in the intermediate freezing levels, and positive charges in the higher freezing levels.

Comparison of the two figures shows both differences and similarities according to the point of view adopted for comparison. If it is assumed that Figure III-1 is more detailed than Figure III-2 and that, therefore, it is reasonable to select only portions of it to show a correspondence with the other, then, starting at the bottom center of III-1, a +, -, + vertical region is found which is also found in III-2.

Williams,[10] in discussing evidence of the lower positive charge, concludes that its location is in the up-draft of the front of the cloud close to the sharp front boundary of the precipitation zone. This location agrees reasonable well with the two figures. Clarence and Malan[10] suggest that if the lower positive charge plays an essential part in cloud-earth lightning, the pattern of ground hits should yield such information. Williams uses observations made by Feteris to show such results.

Chalmers also refers to the investigations by many other researchers, including radar observations of TSTMS. The most interesting is the abrupt appearance of a radar return (Workman and Reynolds) presumed by the authors to be due to the sudden formation of large drops. The top of the radar

APPENDIX III

return begins to rise within the actual cloud, then begins to fall as electrical activity and visible precipitation begins. Reynolds and Brook in similar work conclude from three centimeter echoes that precipitation is a necessary but not sufficient condition for onset of TSTM electrification with a further condition appearing to be rapid vertical development. Moore, Vonnegut, and Botka, using tethered radiosonde measurements, suggest that rapid vertical development is the cause of electrification. A theoretical treatment by Sartor, and another by Frier, produce evidence that coalescence should be increased by an electrostatic field.

It has been observed many times that there is often a heavy downpour of rain shortly after a flash of lightning. Moore, et. al., using radar observations from below a Bahamas thundercloud, noticed that a new echo indicating large drops often appeared shortly after a lightning flash. These data indicate that probably lightning causes the heavy rain rather than the reverse. Moore has reached similar conclusions using New Mexico observations.

Many writers, notably Wall, Kuettner, and Israël, take the view that there is no difference between processes at work in a thundercloud and in a no-thunder shower cloud. In one, the potential gradient reaches the value necessary for a discharge; in the other, it does not. Wichmann puts forward the opposite view: that there is a difference of processes in both kind and degree between a thundercloud and a shower cloud. He contends that the lower positive charge appears to be peculiar to the TSTM, that only when the positive charge exists can the potential gradient be strong enough to produce lightning. Wichmann also points out the rapid dynamic nature of the TSTM which passes through all its phases rather quickly.

Some work has been done in determining the charge potential of minor shower clouds. Tamura, using winter data in Japan, showed that in seven out of ten cases the cloud was negatively charged, which, two out of three times, is thus opposite from the lower positive charge of a TSTM cloud.

The most consistent feature of these works is the apparent inconsistency, suggesting that TSTMS vary widely in make-up from one place to the next. Informal discussions(3)

APPENDIX III

tend to the point of view that knowledge of TSTMS is so sparse that these works and others like them are out of date even before appearing in print. Caution is advised in adopting any of them as a model for showers and TSTMS at KSC. Giving the researcher the benefit of validity of his own observations for the particular time and place, it follows, then, that the best model for KSC showers and TSTMS would be data gathered at KSC.

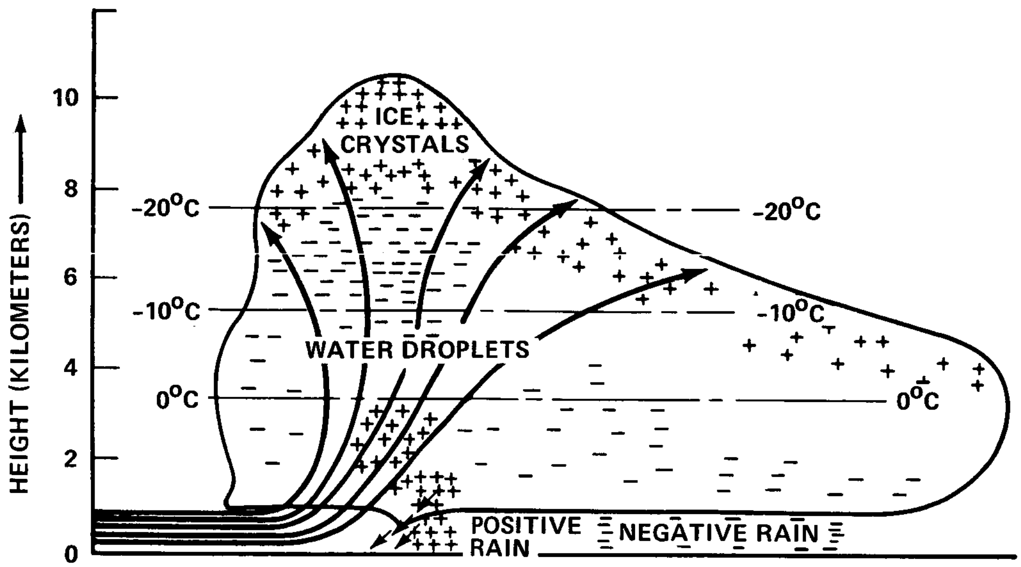
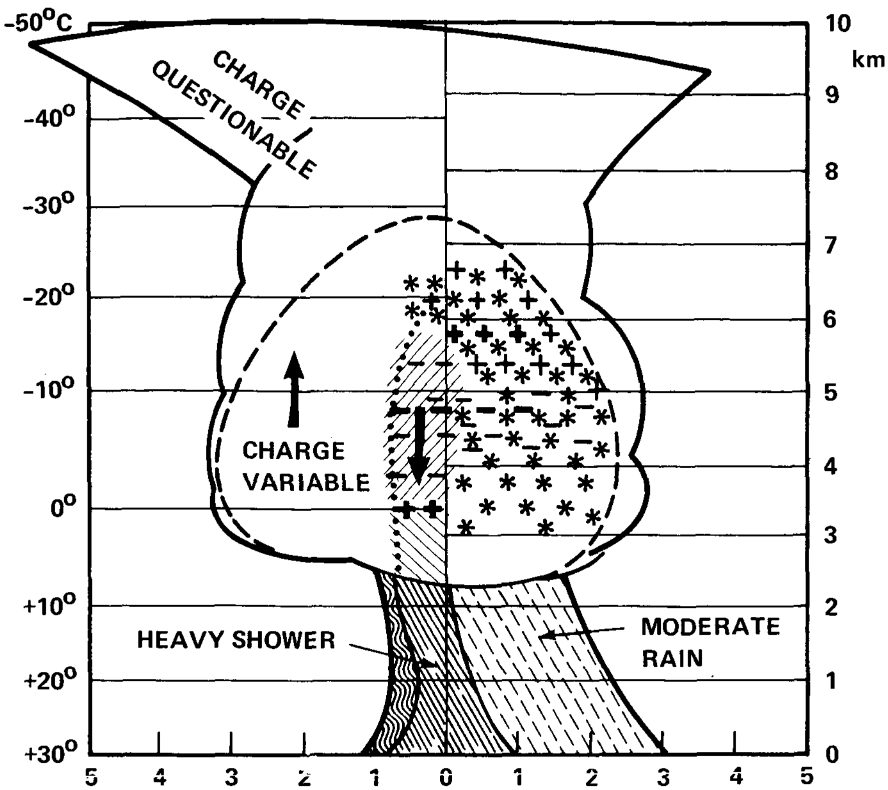


FIGURE III-1 - CHARGE DISTRIBUTION IN TYPICAL AIR - MASS THUNDERSTORM CLOUD.



VERTICAL MOTION OF AIR

BOUNDARY BETWEEN UPDRAFT AND DOWNDRAFT

BOUNDARY OF AREA WITH PRECIPITABLE PARTICLE (RADAR ECHO)

+ − SIGN OF ELECTRIC CHARGE

AREA OF GRAUPEL IN PROCESS OF GROWTH

AREA OF GRAUPEL IN PROCESS OF MELTING

AREA OF SNOW

FIGURE III-2 - CHARGE DISTRIBUTION (KUETTNER) IN CUMULONIMBUS CLOUD.

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